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ORIGINAL ARTICLE

Morbidity and mortality rates after emergency abdominal surgery: an analysis of 4346 patients scheduled for emergency laparotomy or laparoscopy

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Abstract
Purpose Emergency abdominal surgery results in a high rate of post-operative complications and death. There are limited data describing the emergency surgical population in details. We aimed to give a detailed analyses of complications and mortality in a consecutive group of patients undergoing acute abdominal surgery over a 4-year period.
Methods This observational study was conducted between 2009 and 2013 at Copenhagen University Hospital Herlev, Denmark. All patients scheduled for emergency laparotomy or laparoscopy were included. Pre-, intra-, and post-operative data were collected from medical records. Complications were registered according to the Clavien-Dindo classification. Cox regression analysis was performed to identify risk factors for mortality.
Results A total of 4,346 patients underwent emergency surgery, of whom 14 % had surgical complications and 23 % medical complications. The overall 30-day mortality was 8 % with 50 % of those in this group over 80 years of age. The 30-day mortality rates were 0.8 % (95 % CI 0.5–1.1) and 17 % (95 % CI 15.5–18.9), respectively, for the laparoscopy and the laparotomy groups. The overall death rate within 24 h of surgery was 21 %. Several risk factors for 30- and 90-day mortality were identified: age, ASA ≥3 (American Society of Anaesthesiologists physical status classification), performance score (Zubroed/WHOclassification), cirrhosis of the liver, chronic nephropathy, several medical conditions, and malignancy.
Conclusion Almost one in five patients died after emergency laparotomy, of whom one in five died within 24 h of surgery. Predictors for poor outcome were identified.

Keywords Emergency abdominal surgery · Morbidity · Clavien-Dindo classification · Mortality · Risk factors

Introduction

Emergency abdominal surgery is performed in most hospitals, and acute laparotomy is considered a high-risk procedure with significant mortality rates ranging from 14–20 % [1–4]. Advanced age and perioperative conditions like sepsis and dependent functional status increase the mortality rate to over 50 % [5]. There is a huge variation in the organization of emergency departments [6, 7], and there is limited evidence regarding the optimal treatment of patients undergoing emergency surgery [8, 9]. The general surgical population is a broad group of patients suffering from a wide range of conditions and existing comorbidities. Outcomes vary within this very heterogeneous group of patients. In recent years, there has been increasing interest in describing mortality rates especially among the elderly [10–12]. However, the literature is still limited with respect to a detailed presentation of the emergency gastrointestinal (GI) surgical population and the severity of complications in the post-operative period. Population-based analyses often lack detailed information on type and severity of post-operative medical and surgical complications.

Our aim was to give a detailed description of complications and mortality in a consecutive group of patients undergoing acute abdominal surgery in a high-volume university hospital over a 4-year period.

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Methods

The study was conducted between May 2009 and April 2013 at Herlev Hospital, which is one of four acute hospitals in the Capital Region of Denmark. The hospital is a 741-bed university teaching hospital, trauma level 3, and serving a population of 432.000. General surgical emergency admissions consist of approximately 9,000 admissions per year, one third of which undergo acute GI surgery. The hospital has separate admission departments for orthopedic, urological, and gynecological emergencies but neither vascular nor neurosurgery emergency management. It has a 24-h-staffed emergency department and surgery theater with two senior surgeons (two consultants or one consultant and one senior fourth–sixth year resident), two first to third year residents, and two interns/junior doctors on call. This team provides an ongoing clinical management of newly admitted surgical patients and post-operative acute and elective in-patients.

Patient population

All patients admitted to the emergency department and scheduled for any laparotomy or laparoscopic GI procedure were included. In addition to this group of patients, we also included those referred for emergency surgery from other hospitals/departments, those who had elective surgery, and those with a post-operative complication demanding emergency surgical intervention.

Data collection

Data were collected from electronic medical records by seven surgeons from the general surgical department. Demographic data, risk factors like smoking and alcohol habits, and pre-existing comorbidities and conditions were registered. Comorbidity was registered if the condition was being medically treated at the time of admission or if previous treatment for the condition was described in the admission report. Performance score was defined as the patient's level of function and capacity for self-care according to Zubroed/WHO classification [13, 14]. Intraoperative data was collected from the Danish Anesthesia Database (DAD) and from the surgery scheduling software and consisted of type and length of surgery, ASA (American Society of Anaesthesiologists physical status classification) and BMI (body mass index).

Post-operative data consisted of a 30-day morbidity (medical and/or surgical complications), length of stay, and 30- and 90-day mortality. Every collector was instructed, prior to the data collection, in registration of post-operative complications according to the Clavien-Dindo classification (CD). Collectors were instructed according to the clinical examples of complication grades and tested according to the two questionnaires to assess reproducibility [15]. The CD grades any deviation or complication in the post-operative period according to severity and type of management and is widely used for reporting complications after elective surgery [16–18]. In this study, post-operative complications were considered minor if the CD score was 1–2. Such a score arises from any complications handled in the surgical ward, for example correction of electrolytes, blood transfusion, antibiotic treatment, superficial wound infections etc. Complications were considered severe if the CD score was 3–5 and include any complications demanding surgical, radiological, or endoscopic interventions, and/or any complication requiring ICU (intensive care unit) management. Grade 5 is death of the patient.

Statistics

Descriptive statistical analysis was performed using the IBM SPSS Statistics for Windows, Version 19.0. Armonk, NY: IBM Corp.2010 and SAS Enterprise Guide 7.1 2014. Frequencies and percentages were calculated for categorical variables, and chi-squared test was performed. Cox regression analysis (mortality) and multivariate logistic regression analysis (morbidity) were performed using stepwise backwards elimination where the entry value for variables was $p < .05$ and the least significant effect that did not meet the level for staying in the model was removed with each iteration. Removal p value for variables was 0.1. Hazard ratios (HR) and odds ratios (OR) with 95 % CI were given and considered statistically significant if $p < .05$.

Results

Patient population

During the 4-year period, we identified 9,750 patients who underwent surgery in relation to admission to the surgical emergency department. A total of 5,404 patients were excluded due to their having undergone superficial surgery, endoscopic surgery, or because they suffered from gynecological or urological disease. Thus, 4,346 patients were included. Mean age was 50 (range 3–108) years, and 54 % were women. ASA score was ≥3 in 22 % of the cases. BMI was 24 (range 13–53) kg/m^2. Performance score was ≥3 in 6.5 % of the cases, 12 % had a weekly intake of alcohol higher than recommended by the Danish Health and Medicines Authority, and 21 % were smokers. See Table 1 for patient demographics, comorbidities, conditions, and medication. The most common condition in patients was hypertension (22 %) followed by other cardiopulmonary conditions: obstructive pulmonary disease (8 %), ischemic heart disease

Table 1 Demographics according to procedure

All patients, $n = 4346$		Laparoscopic procedure $n = 2453$	Laparotomy $n = 1893$
Age, mean (95 % CI)		38 (17–55)	63 (40–86)
Age, years	<20	561 (23)	154 (8)
	20–39	849 (35)	126 (7)
	40–59	567 (23)	335 (18)
	60–79	380 (15)	774 (41)
	>80	96 (4)	504 (26)
Gender	Male	1091 (44)	893 (47)
WHO performance status	0	2178 (89)	950 (51)
	1	178 (7)	361 (19)
	2	58 (2)	313 (17)
	3	23 (1)	201 (10)
	4	5 (0.2)	50 (3)
ASA score	<III	1902 (78)	1322 (70)
	≧III	489 (20)	538 (28)
Body mass index, kg/m^2	≤18.5	256 (15)	172 (15)
	18.5 ≤ 25	839 (50)	607 (51)
	25 ≤ 30	419 (25)	273 (23)
	>30	177 (10)	127 (11)
Tobacco	Non-smoker	1727 (75)	1055 (61)
	Former smoker (>8 weeks)	131 (6)	241 (14)
	Smoker	440 (20)	423 (25)
Weekly alcohol intake	≤7/14 units	2104 (92)	1406 (84)
Female/male	>7/14 units	182 (8)	280 (16)
Diabetes		63 (3)	138 (7)
Thyroid disorder		57 (2)	96 (5)
Cerebrovascular disease		53 (2)	131 (7)
Hypertension		309 (13)	652 (34)
Atrial fibrillation		41 (2)	137 (7)
Ischemic heart disease		47 (2)	164 (9)
Obstructive pulmonary disease		131 (5)	227 (12)
Chronic nephropathy		19 (1)	61 (3)
Cirrhosis of liver		1 (0)	32 (2)
Malignancy	None	2345 (95.5)	1374 (73)
	Former	68 (3)	192 (10)
	Present, not disseminated	24 (1)	155 (8)
	Present, disseminated	16 (0.5)	172 (9)
Oncological treatment	None	2432 (99)	1730 (91)
	Ongoing or within the last 8 weeks	21 (1)	163 (9)
Medication	Systemic steroid	25 (1)	115 (6)
	Statins	144 (6)	312 (16)
	β-blockers	72 (3)	205 (11)
	Immune modulation therapy	21 (1)	76 (4)
	Antithrombotic therapy	198 (8)	482 (26)

(5 %), and atrial fibrillation (4 %). Metabolic disorder was present in 3.5–5 %, and 8 % had malignant disease. Within the overall population, 86 % had no or one comorbidity registered. Seven percent of patients who had two

or more conditions registered were in the laparoscopic group compared to 24 % in the laparotomy group.

Procedures

The most common procedure was appendectomy followed by diagnostic laparoscopy, colonic resection, and small bowel resection (Table 2). The laparoscopic procedures consisted mainly of low risk procedures like appendectomy, diagnostic laparoscopy, and cholecystectomy in young patients. In this group, 80 % were <60 years of age and 61 % of operations were carried out by juniors (first to third year residents). The laparotomy procedures were primarily high-risk ones due to obstruction or perforation of a hollow viscus in the group of patients >60 years of age (68 %); 77 % of these cases were operated on by fourth–sixth year residents or consultants.

Per-operative results

The average duration of surgery was 63 min (range 26–100) in the group of patients undergoing laparoscopic surgery and 117 (44–190) min in the laparotomy group. Of the 4,346 patients operated on, 10 % needed post-operative mechanical ventilation or dialysis in the ICU, of whom 0.5 % were in the laparoscopic group and 11 % in the laparotomy group. Length of stay in hospital was on average 2 days (0–75) in the laparoscopic group and 8 days (0–210) in the laparotomy group.

Mortality

The overall 30-day mortality was 8 % (345/4346). Of these, 50 % were over 80 years of age, 42 % were 60–79 years of age, and 8 % were less than 60 years of age. Death within the first post-operative day occurred in 72 patients (21 % of those who died within 30 days). Most of these patients had severe septic shock and multi-organ failure (81 %) or died of severe cardiopulmonary incidents (15 %). The cause of death was registered as death by medical complications in 274 patients (79 %) and death by surgical complications in 28 patients (8 %). Malignant disease was present in 32 %.

Death within 30 days but not in hospital occurred in 43 cases, for which the cause of death was not classified, and 58 % of these patients were registered as having malignant disease.

The overall procedure-related 30-day mortality is shown in table 2. In the laparoscopic group, a 30-day mortality was 0.8 % (by procedure: 0.3 % cholecystectomy, 0.4 % appendectomy, 8.3 % gastric- or duodenal procedure, and 6.4 % colonic surgery) and the 90-day mortality was 1.2 %. The 30-day mortality in the laparotomy group was 17 % (by procedure: 9 % cholecystectomy, 1.5 % appendectomy, 31 % gastric- or duodenal procedure, and 21 % colonic surgery), and the 90-day mortality was 23.0 %.

To estimate risk factors for 30- and 90-day mortality, we performed a multivariate Cox regression analysis. The analysis assessed gender, age, ASA score ≥3, performance status ≥3, and comorbidities: diabetes, thyroid disease, cerebrovascular disease, hypertension, atrial fibrillation, ischemic heart disease, obstructive lung disease, chronic nephropathy, cirrhosis of the liver, malignant disease, use of steroids, statins, or immune modulation therapy.

We estimated several predictors for death (30-and 90-day mortality), shown as hazard ratios in table 3. Predictors of short-term mortality were advancing age, ASA ≥3, performance status, and the presence of severe illness such as cirrhosis of the liver, chronic nephropathy, ischemic heart disease, atrial fibrillation, cerebrovascular disease, malignancy, and oncological treatment. The patients undergoing open procedures had an HR of 5.4, 95 % CI (3.3–8.7), and $p < 0.01$. Predictors of the 90-day mortality were advancing age, performance status, malignancy, obstructive pulmonary disorder, and cerebrovascular disease. The patients undergoing open procedures had an HR of 4.8, 95 % CI (2.3–9.9), and $p < 0.01$. There was a reduction in the 30-day mortality associated with statin therapy HR 0.7, 95 % CI (0.5–0.9), and $p = 0.009$. We found no influence on mortality by rank of the operating surgeon nor any of the other medications investigated. Data not presented here.

Complications

One or more post-operative surgical complications occurred in 14 % of the population, of whom 81 % were in the laparotomy group. Post-operative morbidity by incident is shown in Table 4. The most common surgical complication was wound infection followed by bleeding. The third most common surgical complication was post-operative ileus. In 50 % of cases, it was registered as a minor complication, treated with IV fluids, nasogastric tube, and/or pro-kinetic agents. The other 50 % required re-laparotomy. Anastomotic leakage occurred in 2 % (4/195) of patients who had a small bowel anastomosis and 2.8 % who had an ileo-colonic (4/151) or colo-colonic (1/26) anastomosis. Re-perforation after suturing of a gastric or duodenal ulcer or leakage from a gastroenteroanastomosis occurred in 6 % (9/153) of the patients. The most common reason for severe surgical complication in the laparoscopic group was intra-abdominal abscess. The most common reason for severe surgical complications in the laparotomy group was re-laparotomy due to various reasons shown as “other” (stoma complications, gastric ulcers, serosal injury, iatrogenic lesion, or various less common complications).

Within the overall population, 23 % of the patients had one or more medical complications. Eighty-eight percent (1388/1586) of the incidents were in the laparotomy group. Cardiopulmonary incidents were the most common and serious complications followed by renal

Table 2 Procedure performed and procedure-related 30-day mortality

Type of surgery	Laparoscopy *n* (%) 2453 (100)	Laparotomy *n* (%) 1893 (100)	All procedures (%) *n* = 4346 (100)	Procedure-related 30-day mortality (%) *n* = 345
Appendectomy	1539 (63)	267 (14)	1806 (41)	10 (0.6)
Hernia repair	21 (1)	187 (10)	208 (5)	7 (3.4)
Diagnostic laparoscopy	498 (20)		498 (11.5)	8 (1.6)
Exploratory laparotomy		197 (10)	197 (4.5)	70 (35.5)
Gastric/duodenal procedure	12 (0.5)	141 (7.5)	153 (3.5)	44 (29)
Small bowel obstruction	19 (0.8)	216 (11.5)	235 (5.5)	20 (8.5)
Small bowel resection/enterotomy	5 (0.2)	378 (20)	383 (9)	86 (22.5)
Large bowel resection/colostomy	47 (2)	411 (22)	458 (10.5)	90 (20)
Cholecystectomy	312 (12.5)	34 (2)	346 (8)	4 (1)
Re-operation elective surgery	0 (0)	40 (2)	40 (1)	4 (10)
Other	0 (0)	22 (1)	22 (0.5)	2 (9)

complications. Severe cardiac complications (166 incidents) consisted primarily of heart failure or cardiac arrest but in which no treatment was initiated due to underlying malignant disease, severe septic shock, or multi-organ failure. Of all the severe cardiac incidents, 100 (60 %) lead to death. The severe pulmonary complications consisted mainly of pneumonia and pleural effusion; 40 % had a fatal outcome. Among the renal complications, 94 % of the cases were acute renal failure/ATN (acute tubular necrosis) with 31 % having a fatal outcome.

Thromboembolic events were a rare complication but fatal in 38 % of the cases. Joint risk factors for severe cardiopulmonary events were identified (Table 5). Predictors on 30-day severe cardiopulmonary morbidity were advancing age, open procedure, performance status ≥3, ischemic heart disease, obstructive pulmonary disorder, and cirrhosis of the liver. Specific predictors

Table 3 Risk factors 30- and 90-day mortalities after emergency surgery

		HR	95 % CI	*p* value	HR	95 % CI	*p* value
		30-day mortality			31–90-day mortality		
Age years	<40			<.001			.005
	41–60	5.5	(16–18.6)	.006	5.0	(1.1–23)	.036
	61–80	11.1	(3.4–36)	<.001	5.3	(1.2–23)	.027
	>80	20.2	(6.2–66)	<.001	7.3	(1.6–33)	.009
ASA	≥3	1.9	(1.5–2.4)	<.001	1.1	(0.8–1.7)	.518
WHO performance status	0			<.001			<.001
	1	1.7	(1.2–2.4)	0.05	1.8	(1.0–3.3)	.043
	2	2.0	(1.4–2.8)	<.001	2.9	(1.6–5.0)	<.001
	3	3.7	(2.6–5.3)	<.001	4.8	(2.6–9.0)	<.001
	4	4.4	(2.6–7.4)	<.001	3.6	(1.3–9.4)	.011
Cerebrovascular disease		1.4	(1.0–1.9)	.05	1.8	(1.0–3.1)	.037
Atrial fibrillation		1.5	(1.1–2.0)	.015	1.0	(0.5–2.0)	1.0
Ischemic heart disease		1.6	(1.2–2.2)	.002	1.0	(0.5–2.0)	0.97
Obstructive pulmonary disorder		1.5	(1.1–1.9)	.004	2.2	(1.4–3.4)	.001
Cirrhosis of the liver		3.3	(1.8–5.8)	<.001	0.6	(0.1–4.3)	0.57
Chronic nephropathy		2.2	(1.4–3.3)	<.001	1.5	(0.5–4.1)	0.45
Malignancy		1.9	(1.4–2.5)	<.001	5.4	(3.7–7.9)	<.001
Laparotomy		5.4	(3.3–8.7)	<.001	4.8	(2.3–9.9)	<.001
Oncological treatment		1.7	(1.2–2.4)	.006	0.9	(0.5–1.6)	.67
Statins		0.7	(0.5–0.9)	.009	1.2	(0.7–1.7)	.43

Table 4 Post-operative complications

Clavien-Dindo classification (CD)	All patients $n = 4346$	Laparoscopic procedure, n (%)			Laparotomy, n (%)		
	Yes/n, n (%)	$n = 2453$	CD 1–2	CD 3–5	$n = 1893$	CD 1–2	CD 3–5
Surgical complications							
Bleeding	121/4225 (2.8)	20 (0.8)	10 (0.4)	10 (0.4)	101 (5.3)	62 (3.3)	39 (2)
Fascia dehiscence	81/1812 (5) ($n = 1893$)	0 (0)	0 (0)	0 (0)	81 (5)	9 (0.5)	72 (4)
Ileus	74/4272 (1.7)	12 (0.5)	5 (0.2)	7 (0.3)	62 (3.3)	32 (1.7)	30 (1.6)
Wound infection	196/4150 (4.5)	15 (0.6)	11 (0.4)	4 (0.2)	181 (10)	125 (6.6)	56 (3)
Intraabdominal absces	130/4216 (3)	60 (2.4)	10 (0.4)	50 (2)	70 (3.7)	8 (0.4)	62 (3.3)
Anastomotic leekage/re-perforation	18/521 (3) ($n = 539$*)	1 (2) ($n = 47$)	0 (0)	1 (2)	17 (3.5) ($n = 492$)	5 (1)	13 (2.5)
Other	190/4320 (4.5)	43 (1.8)	10 (0.4)	33 (1.4)	147 (7.8)	32 (1.7)	115 (6.1)
Medical complications							
Neurological	117/4239 (3)	13 (0.5)	11 (0.4)	2 (0.1)	104 (5.5)	77 (4.1)	27 (1.4)
Respiratory	440/3906 (10)	47 (2)	27 (1.1)	20 (0.8)	393 (21)	176 (9.3)	217 (11.5)
Cardiac	310/4036 (7)	37 (1.5)	22 (0,9)	15 (0,6)	273 (14)	122 (6.4)	151 (8)
Gastrointestinal	421/3925 (9)	67 (2.7)	65 (2.6)	2 (0.1)	354 (19)	300 (15.8)	54 (2.9)
Renal	272/4074 (6)	32 (1.3)	26 (1.1)	6 (0.2)	240 (13)	127 (6.7)	113 (6)
Tromboembolic	26/4320 (0.6)	2 (0.1)	0 (0)	2 (0.1)	24 (1.2)	12 (0.6)	12 (0.6)

CD 1–2 Clavien-Dindo classification mild post-operative complications, *CD 3–5* Clavien-Dindo classification severe post-operative complications

*Anastomosis or suturing of ulcer at primary operation

for cardiac morbidity were ASA score ≥3, diabetes and use of systemic steroids, and for pulmonary morbidity; cerebrovascular disease.

Discussion

To our knowledge, no other population-based analysis on emergency abdominal surgical patients has the detailed information on type and severity of post-operative medical and surgical complications as presented in this study.

Patient population

We found the emergency surgical population to be greatly heterogeneous and yet to represent two large groups. The first group is mainly younger patients with acute abdomen of mainly underlying benign disease, with less comorbidity, most of them undergo laparoscopic surgery, having short length of stay, fewer surgical and medical complications, and lower mortality. The second group consisted of patients who underwent laparotomy, primarily over 60 years of age with more comorbidities and largely severe cause of acute abdomen such as perforation of a hollow viscus, ileus or malignant disease, and with the majority of severe post-operative complications and fatalities.

Procedures

Laparoscopic surgery is widely accepted for most elective gastrointestinal surgical conditions with outcomes similar to conventional operations. It has also become a routine procedure for abdominal emergencies both as a diagnostic tool and as a therapeutic tool in managing e.g., acute appendicitis, acute cholecystitis, and some cases of perforated peptic ulcers [19–22]. In recent years, it has even been used in some cases of small bowel obstruction and acute colorectal emergencies such as diverticulitis and iatrogenic colon perforation [23–25].

In our study, the low morbidity and mortality rates in the laparoscopic group testify to the safety of laparoscopy and show how well established the practice is in an emergency setting for what are generally minor procedures. We found a lower 30-day mortality in the laparoscopic versus open surgery groups for perforated ulcer (8.3 and 31 %, respectively) and for emergency colonic surgery (6.4 and 21 %, respectively). We believe that some of the difference in mortality is due to selection of patients, since laparoscopic surgery was probably undertaken only if the underlying disease/pathology was less severe. Perforated ulcers of smaller sizes, iatrogenic colonic perforation with less abdominal contamination etc. could be handled laparoscopically, and procedures were most likely converted to open surgery if underlying malignant disease was present or the abdominal cavity was very contaminated. In this study, we cannot draw conclusions about the safety of major procedures such as perforated ulcer or emergency colonic surgery or on whether laparoscopic procedure should always be

Table 5 Risk factors of 30-day morbidity after emergency surgery

		OR	95 % CI	*p* value	OR	95 % CI	*p* value
		Pulmonary morbidity CD 3–5			Cardiac morbidity CD 3–5		
Age years	<40			<.001			<.001
	41–60	4.9	(1.6–15)	.004	7.3	(1.6–32)	.009
	61–80	14.5	(5.2–41)	<.001	13.9	(3.2–59)	<.001
	>80	14.9	(5.2–42)	<.001	24.8	(5.8–106)	<.001
Open procedure		5.4	(3.3–8.8)	<.001	4.1	(2.3–7.2)	<.001
ASA	≥3	.94	(0.7–1.3)	.743	1.8	(1.3–2.5)	.001
WHO performance status	≥3	1.7	(1.2–2.5)	.003	2.3	(1.6–3.4)	<.001
Malignancy		1.3	(0.9–1.9)	.160	1.2	(0.8–1.8)	.224
Cerebrovascular disease		1.7	(1.1–2.7)	.013	0.9	(0.5–1.6)	.647
Diabetes		1.2	(0.8–1.9)	.407	2.4	(1.5–3.8)	<.001
Thyroid disease		0.9	(0.5–1.6)	.775	1.1	(0.6–2.1)	.469
Hypertension		0.9	(0.7–1.3)	.665	1.1	(0.8–1.6)	.413
Atrial fibrillation		1.3	(0.8–2.0)	.291	1.3	(0.8–2.2)	.279
Ischemic heart disease		1.5	(1.0–2.3)	.045	2.2	(1.4–3.4)	<.001
Obstructive pulmonary disorder		2.5	(1.7–3.5)	<.001	1.6	(1.1–2.4)	.028
Cirrhosis of the liver		2.7	(1.2–6.6)	.020	2.7	(1.0–7.0)	.043
Chronic nephropathy		2.3	(1.2–4.1)	.009	1.8	(0.9–3.6)	.068
Steroid		1.5	(0.9–2.5)	.185	2.3	(1.4–4.0)	.002

OR odds ratio and *CD* Clavien-Dindo score

the first choice in such cases; but we do believe it to be safe for a selected group of patients.

Mortality and complications

Only one previous study, in Finland [18], retrospectively analyzed a smaller group ($n = 444$) of emergency surgical patients and validated the Clavien-Dindo classification for emergency surgical patients. They found a mortality rate of 18.2 % in the laparotomy (cf 17 % in our results) versus 0.7 % in the laparoscopic group (cf 0.8 % for us). We characterized the groups further finding that medical complications were registered as the cause of death in four out of five patients. An important finding here was the high incidence of cardiopulmonary complications, which was also consistent with earlier findings. One study reported cardiopulmonary incidents in 26 % of laparotomies, and post-operative respiratory incidents have been described as between 5 and 10 % following abdominal surgery, with the higher rate in the emergency surgery group [26–28]. Preventing or minimizing cardiopulmonary complications demands the optimal per and post-operative surveillance and care. No registration of the pre-operative ventilation strategy was done in our study, but lung-protective ventilation has been suggested as a strategy in previous studies. A multicenter trial carried out in 2013 [29] randomized patients undergoing major abdominal surgery to either pre-operative lung-protective ventilation with the use of low tidal volumes and positive-end expiratory pressure or to standard mechanical ventilation. They showed that the intervention significantly reduced major pulmonary complications within the first post-operative week from 27.5 to 10.5 %. We also suggest that these patients be assessed and post-operatively closely monitored, possibly in a setting with intermediate beds or critical care beds, since it is likely that post-operative complications might be detected earlier, and so treated in time which might increase survival [30, 31].

This study found a 30-day mortality of 17 % after emergency laparotomy with 50 % of patients over 80 years of age, which is consistent with results published previously. A large retrospective study from the USA [5] with 37,553 patients found an overall 30-day mortality rate of 14 % and of more than 50 % with ASA IV or V, dependent functional status and septic shock, and less than 10 % chance of survival in the same group for those aged 90 or more. We also identified advancing age and performance status to be strong, independent predictors for increased morbidity and 30-day and 90-day mortalities. In our study, almost one out of five patients died within the first 24 h after surgery. Age and performance status are easy tools to help predict survival and might give the team of surgeons and anesthesiologists better guidance of treatment to this group of severely ill patients. In the first place, this would give the team strategies to identify patients who are not likely to survive an emergency procedure and thereby giving them a tool to aid the choice of a non-operative strategy

in the very difficult and delicate situation of choosing a palliative strategy. Secondly, this would give patients and/or relatives a better chance of informed consent if emergency surgery is the choice of management.

The presence of co-existing medical disease is of great importance for the prognosis of patients undergoing emergency surgery. Age, ASA class, functional status, and presence of sepsis have been shown to predict death [5, 12, 32], and several studies have tried to develop scoring systems in order to be able to predict outcome by scoring pre-operative status; however, literature is not consistent concerning the impact of comorbidities in general [10, 33–35]. We found the presence of cerebrovascular disease, cardiopulmonary conditions, chronic nephopathy, cirrhosis of the liver, and malignancy to influence the 30-day mortality and cerebrovascular disease, obstructive pulmonary disorder, and malignancy to influence the 90-day mortality as well.

An interesting finding here was a reduced 30-day mortality with the use of statins. The use of statins has previously been associated with reduced mortality and cardiovascular outcomes in non-cardiac surgery [36], but there are no such studies on the emergency GI population for comparison.

We suggest that the Clavien-Dindo classification is used for monitoring post-operative morbidity and mortality and emphasizes the importance of ongoing and future research and outcome measurements on emergency surgical patients. There is a need for high-quality prospective and multimodal intervention studies in order to improve patient care in this large group of patients, especially the laparotomy group.

Limitations

This study has a number of limitations including the fact that it is a single-center retrospective observational study which makes generalizations difficult. We had seven data collectors but tried to assure collection of high-quality data and to minimize the risk of inter-rater disagreement by instructing the collectors to follow a standardized manual and by providing training in the CD classification as previously described. This study included a large volume of patients with few missing data, but unfortunately BMI is missing in 34 % and smoking habits in 8 % of the cases.

Conclusion

In conclusion, we achieved to give a detailed analysis of complications and mortality in a consecutive group of patients undergoing acute abdominal surgery. We found that almost one in five patients died after emergency laparotomy of whom one in five died within 24 h of surgery and identified several risk factors for mortality and severe cardiopulmonary events.

Compliance with ethical standards This research was approved by the Danish Data Protection Agency; HEH-2013-034 I-Suite no: 02336. There was no requirement for approval by The National Committee on Health Research Ethics as the study was a non-interventional non-biomedical project. Mai-Britt Tolstrup MD, Sara Kehlet Watt MD, and Ismail Gögenur MD, DMSc declare that none of them has any conflict of interest. No external funding has been received to support this study.

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